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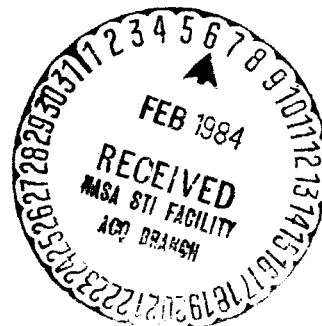   Santa Barbara, CA 93106

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Quarterly Progress Report, Contract No. NAS5-27463
Landsat-D Investigations in Snow Hydrology

Reporting Period: October 1 to December 31, 1983

Atmospheric Model Development

ATRAD, an atmospheric radiative transfer calculation program, calculates azimuth-dependent or azimuth-independent radiance/radiative fluxes at any level in an arbitrarily specified inhomogeneous atmosphere that is approximated by a finite number of plane-parallel homogeneous sublayers with different radiative properties. The code is modified from Warren Wiscombe's ATRAD80, which calculates only azimuthally-averaged radiances. Absorption and scattering by aerosols, clouds, and all natural atmospheric gases are included.

Optical properties of aerosols are treated in a way similar to LOWTRAN5. The combined line absorption and scattering is treated without recourse to extremely narrow spectral intervals by fitting transmissions with exponential sums. The exponential fits are calculated by a separate program and read from a table by ATRAD. Similarly, the Mie phase function parameters can be read from tables or calculated for any layer. The maximum number of types of Mie scatterers in a single layer is two, one read from a table, and the other calculated at run time from number density, droplet size distribution, and refractive index (but supported for only ice and water at present). In the wavelengths of significant emitted radiation, the atmospheric emittance and surface emissivity are considered. The range of wavelengths that ATRAD can cover is 0.2 to 500 μm.

ATRAD offers high flexibility in the specification of surface boundary conditions. There are two major options:

1. For complete calculation the user must supply eight input files: wavelengths, angles, solar radiation at top of atmosphere, atmospheric profile, surface conditions, Mie properties of atmospheric constituents, exponential fit parameters, and output control options.

2. Intermediate results from the option described above can be saved for later calculation with different bottom boundary conditions. This saves more than 90% of the computation time compared with the complete calculation.

So far we have completed ATRAD and its supporting programs (setting up atmospheric profile, making Mie tables and exponential-sum-fitting table). More sophisticated treatment of aerosol scattering (including angular phase function or asymmetric factor) and multi-channel analysis program of results from ATRAD are being developed.

In addition to our work on ATRAD, some progress has been made on a Monte Carlo program for examination of two-dimensional effects, specifically a surface boundary condition that varies across a scene. MONTE is a program that combines ATRAD and the Monte Carlo method together to produce an atmospheric point-spread function. The latter would be useful for retrieving the ground upwelling radiance from the space measurement of radiance. Currently the procedure passes monochromatic tests, and the results are reasonable. The format for using the program is very similar to that for ATRAD, except that an additional input file that specifies some input parameters for the Monte Carlo procedure is needed: the number of photons fed, cosine of incidence angle, sampling radius, polar angles, and zenith and azimuth angles. The resulting point-spread function can be either two-dimensional for a Lambertian surface to describe the location dependence of the spread function, or four-dimensional for an anisotropic surface to depict both spatial and angular characteristics of the point-spread function of the atmosphere.

Further effort will be made to compare its results with what obtained from ATRAD, to extend the procedure to cover wider spectral bands, to reduce the computation time, and to make some statistical manipulations to smooth the point-spread function, which originally is somewhat irregular because of the random nature of the Monte Carlo procedure.

Publications

1. Snow Reflectance from Landsat-4 Thematic Mapper, accepted for publication in *IEEE Transactions on Geoscience and Remote Sensing* (copy attached).